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Greenhouse Gases, Climate Change, Carbon Sequestration, and Carbon Credit Trading

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Areas to Cover:

- Characteristics of Light
- Earth's Radiation Balance
- Greenhouse Effect
- Greenhouse Gases
- Agricultural Mitigation of GHG's
- Methods to Estimate GHG's

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Characteristics of solar and terrestrial radiation

To understand why greenhouse gases in the atmosphere are an issue, we must first discuss radiation transfer within the atmosphere.

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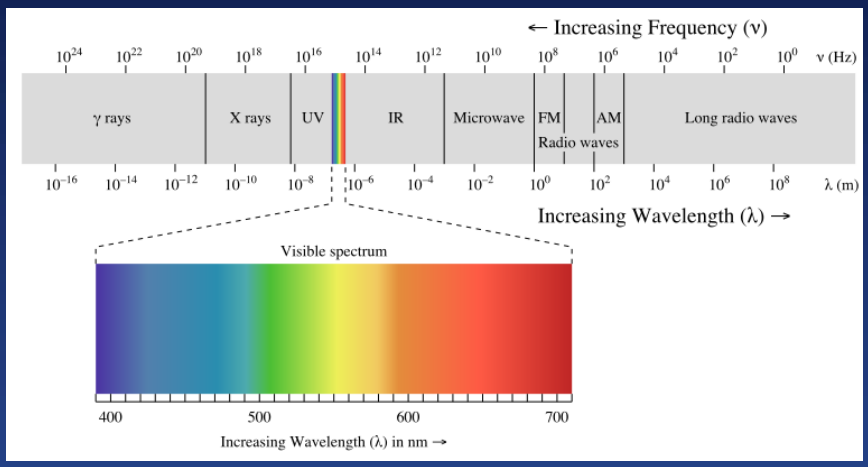

Solar energy is made up partly of visible light (ROYGBIV), as well as some ultraviolet and infrared light.

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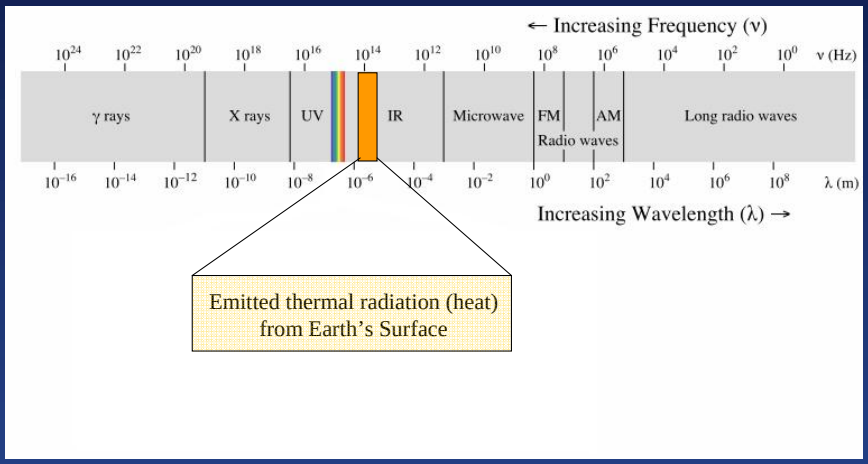

Some radiation from the sun is reflected by the earth, the rest is absorbed. This absorbed radiation heats the earth surface, which then in turn emits heat/thermal radiation back to the atmosphere and space.

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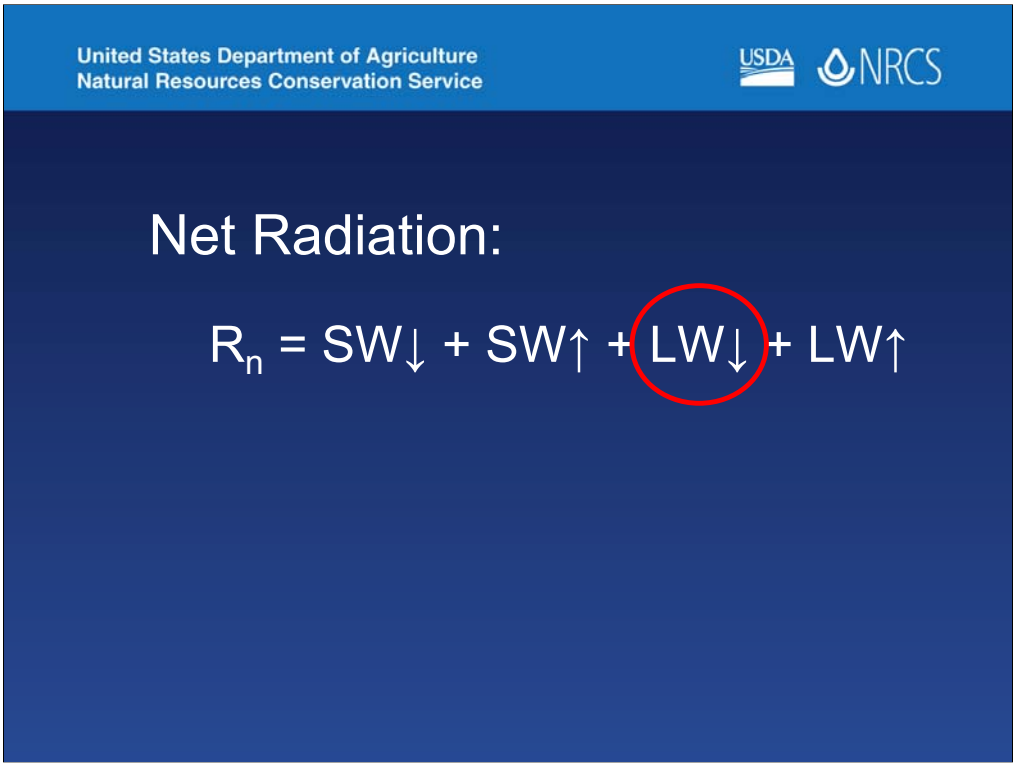
What happens to light at the earth's surface?

- Reflected (albedo)
- Absorbed
  - Heat Surface
  - Heat/Evaporate Water
  - Photosynthesis

- Shortwave Radiation
  - From Sun
  - Visible Light
  - Reflected and Absorbed by Earth
- Longwave Radiation
  - Emitted from Earth
  - Heat (Thermal)



The simple equation for net radiation balance: Rn – Net Radiation, SW is shortwave (solar) radiation, LW is longwave (terrestrial) radiation. The greenhouse effect provides the incoming longwave radiation.

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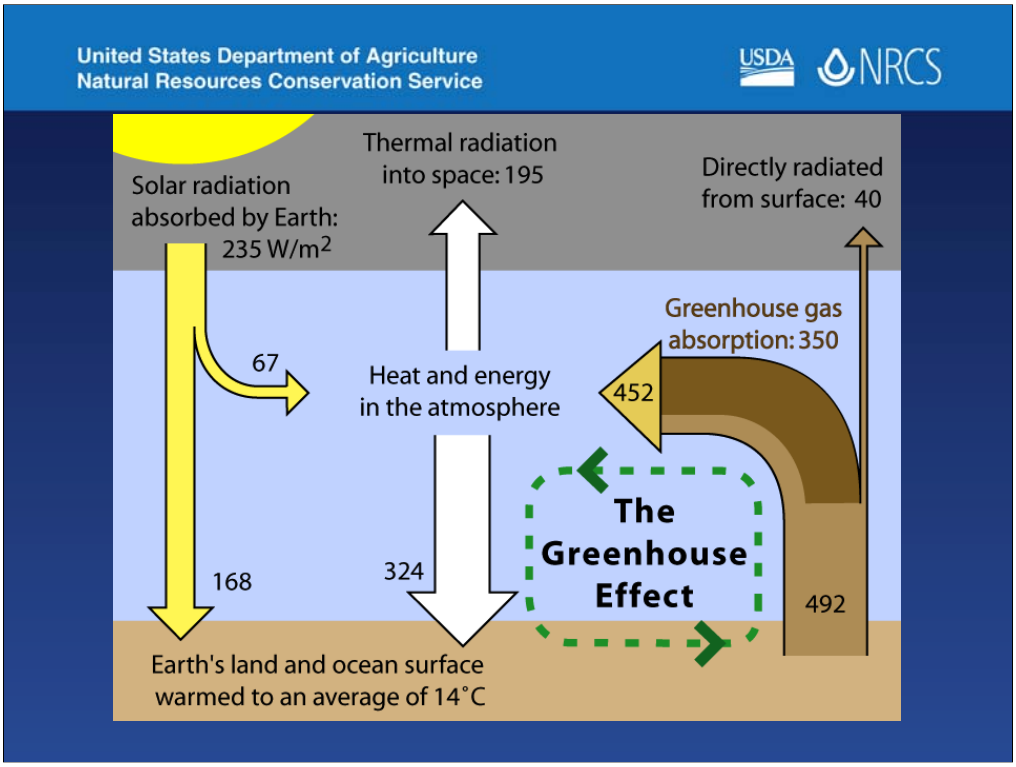
Greenhouse Effect and Greenhouse Gases

The **greenhouse effect** is the process in which the absorption and emission of thermal infrared radiation (heat) by a planet's atmosphere warms that planet's surface.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NRCS
Thermal radiation into space: 195
Directly radiated from surface: 40
Solar radiation absorbed by Earth: 235 W/m2
Greenhouse gas absorption: 350
67
Heat and energy in the atmosphere
452
The Greenhouse Effect
168
324
492
Earth's land and ocean surface warmed to an average of 14˚C

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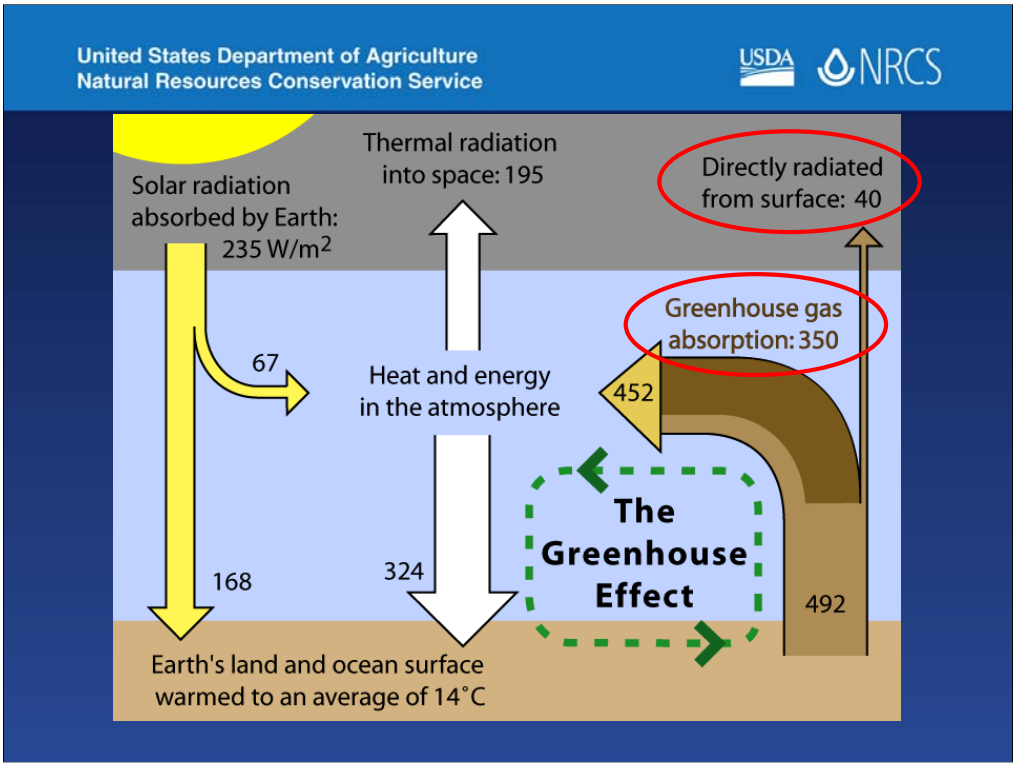
Earth's average temperature is 15 C (59°F)

Without the greenhouse effect, the Earth's average temperature would be 0°F



The big concern with increasing atmospheric concentrations of greenhouse gases is that the greenhouse gas absorption portion of the radiation balance with increase, trapping more heat in the atmosphere and increasing the global temperature, thus global warming.

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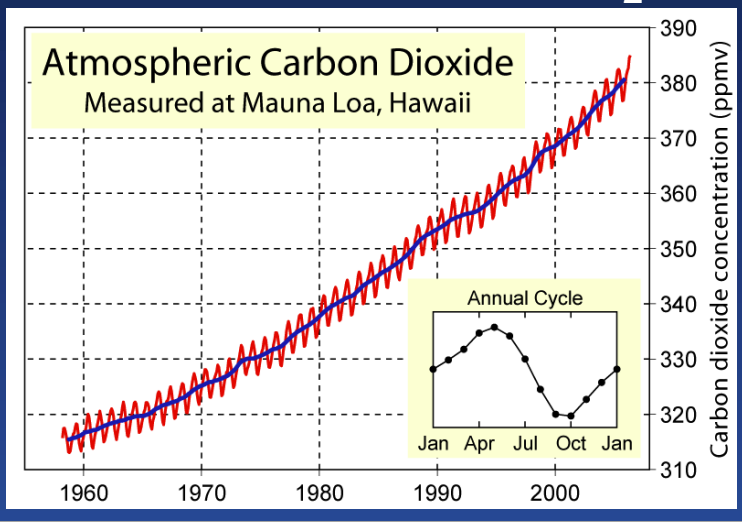
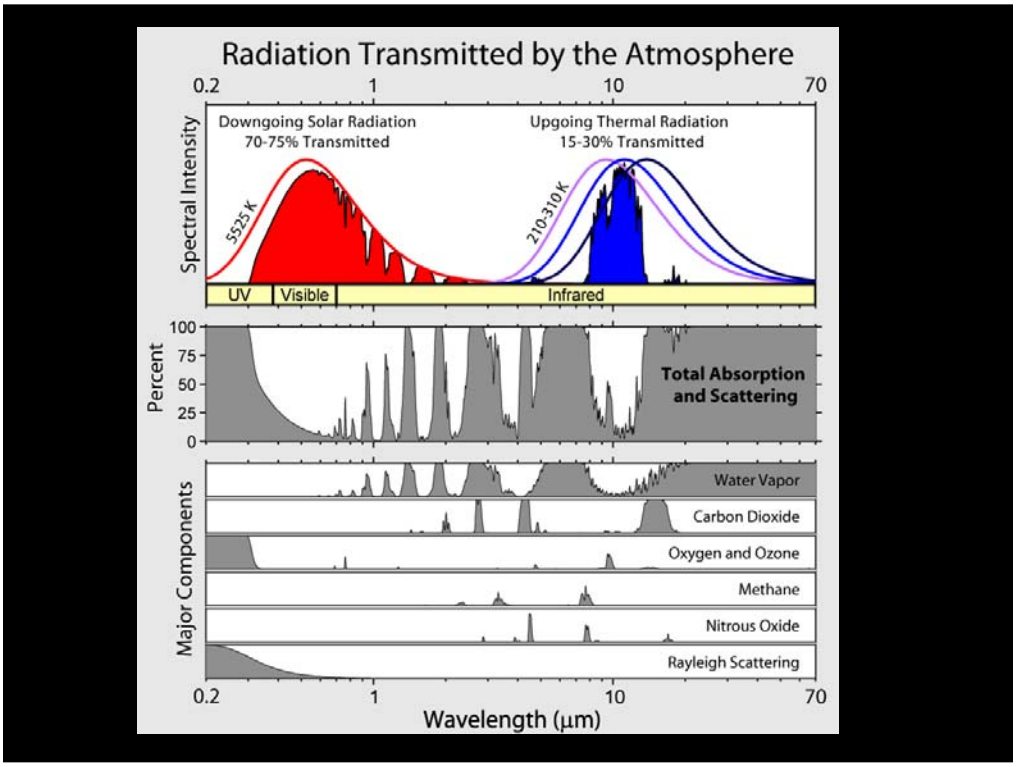
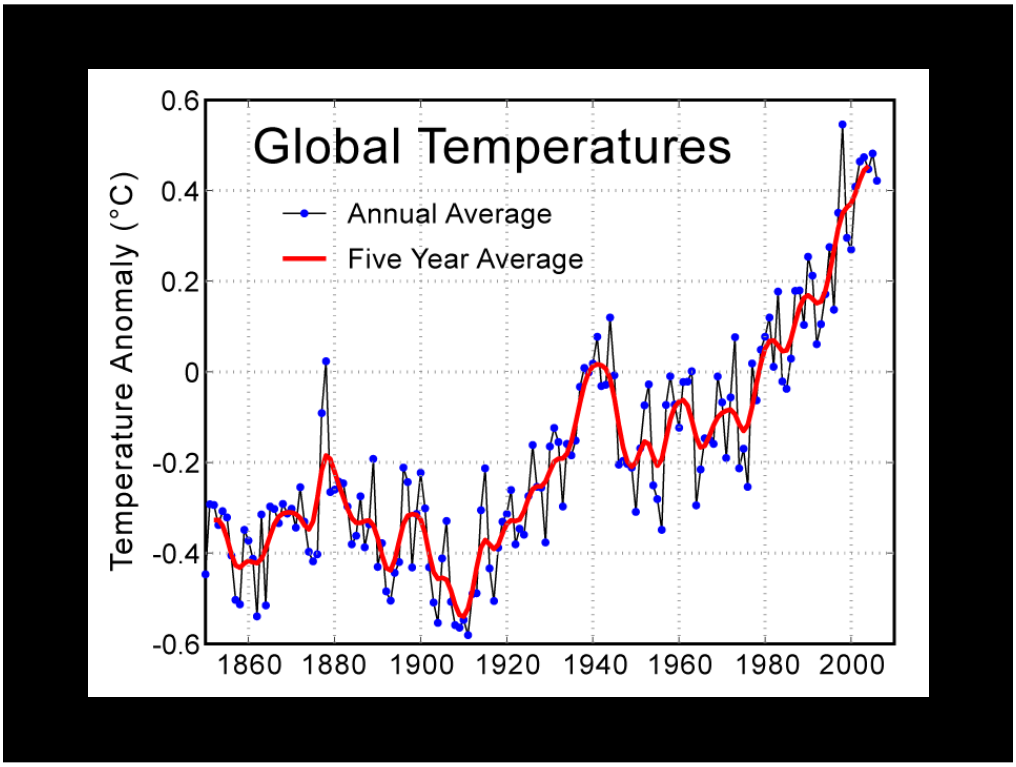
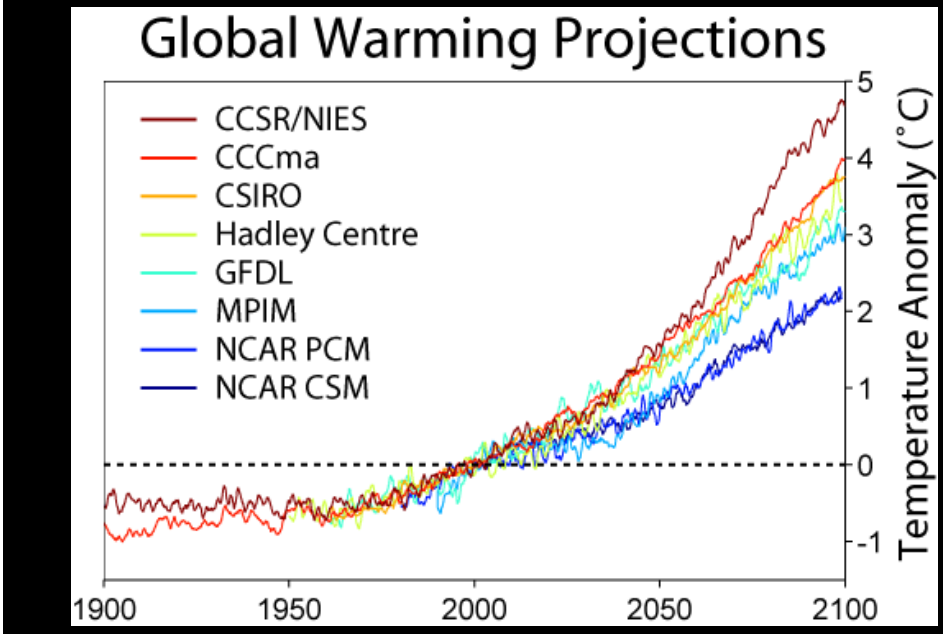
Increasing Atmospheric Concentrations of CO_2




Radiation Transmitted by the Atmosphere
0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
0.2
1
10
70
Wavelength (μm)


Global Temperatures
Annual Average
Five Year Average
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1860
1880
1900
1920
1940
1960
1980
2000


Global Warming Projections
CCSR/NIES
CCCma
CSIRO
Hadley Centre
GFDL
MPIM
NCAR PCM
NCAR CSM
5
4
3
2
1
0
-1
Temperature Anomaly (°C)
1900
1950
2000
2050
2100

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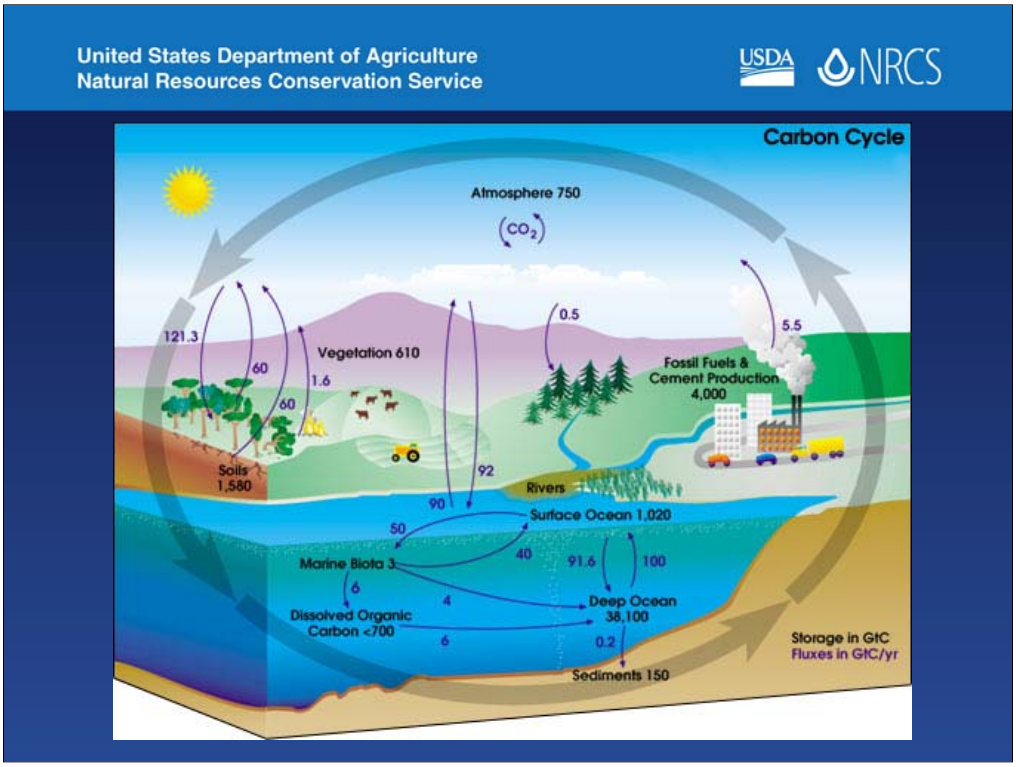
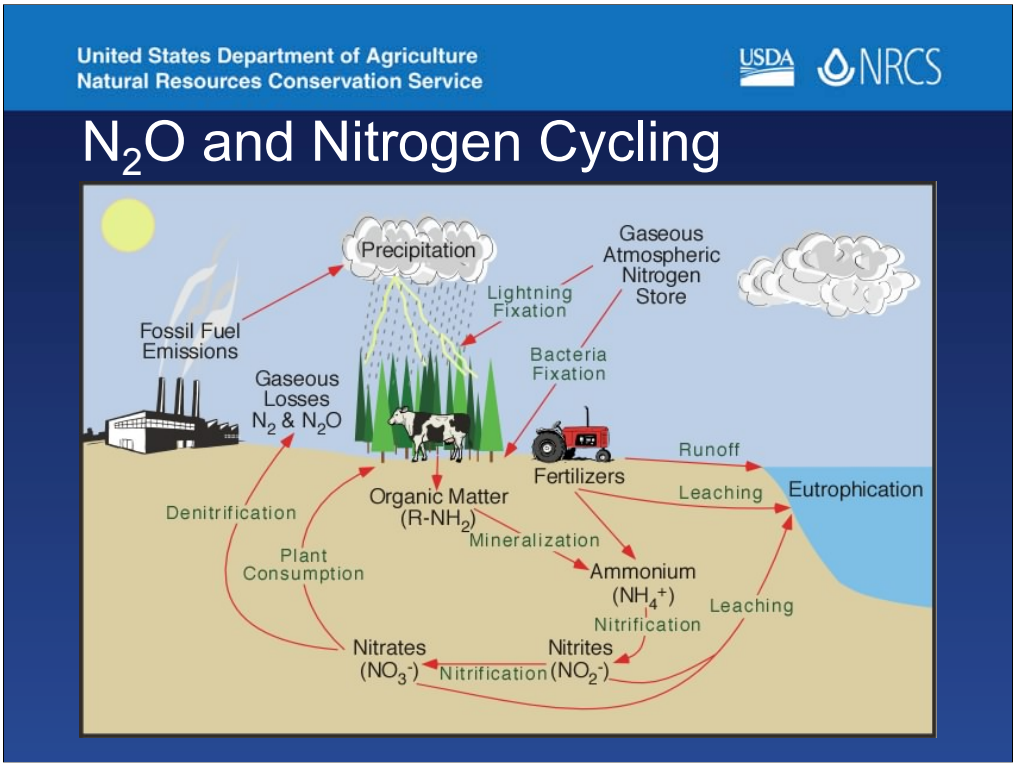
What are Some Greenhouse Gases?

- CO_2
- N_2O
- CH_4
- H_2O
- Ozone
- Fluoromethane compounds



Carbon Cycle. Graphic shown to depict the wide array of sources and sinks of carbon in the environment. Note that while soils are an important storage point for carbon, the oceans, in particular the deep oceans, have the largest overall carbon storage of any mechanism.



Graphic representing the nitrogen cycle. Identifies the nitrification/denitrification reactions as the primary source of N2O.

- For accounting purposes, greenhouse gases are counted in ***carbon dioxide equivalents***:
  - CO_2 = 1 CO_2 equivalent
  - CH_4 ~ 20 CO_2 equivalents
  - N_2O ~ 300 CO_2 equivalents

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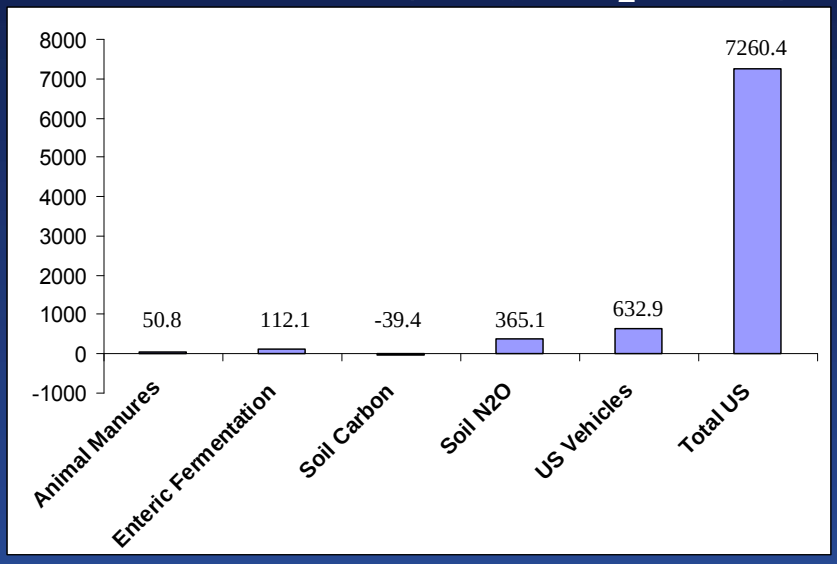
GHG Emissions (in Tg CO_2 Equiv)



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Agricultural Sources of GHG's

- CO_2
- N_2O
- CH_4

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Carbon Dioxide

- Engine Combustion
- Soil Tillage
- Biomass Burning

Anthropogenic agricultural sources of carbon dioxide. This list does not include natural sources of CO2 like soil respiration, microbial activity, natural decomposition processes.

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Nitrous Oxide

- Nitrogen conversions in soil and manure piles

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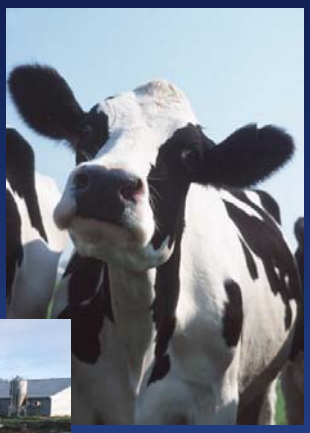
Methane

- Predominantly from animal production and manure storage



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Offsetting GHG Emissions

- Emissions Reductions (CO_2, CH_4, N_2O)
- Carbon Sequestration (CO_2)

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Emissions Reductions

- Fewer, or combined trips/passes
- Reducing tillage
- Alternate/renewable fuels

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Reduce CO_2 Emissions

- Reduced Trips
  - Reduced Tillage
  - No-Till
  - Combining Operations

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N_2O Reductions - Nutrient Management

- Control Nitrogen Applications
- Reduce Nitrification/Denitrification
- Improve Scouting, Soil Sampling

N2O emissions can be reduced by splitting applications of nitrogen fertilizers, applying only for crop needs, and utilizing nitrification inhibitors. Storing manures dry can help reduce N2O losses from solid manure piles.

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Methane Reduction and Capture

- Use an aerobic manure system
- Capture methane with digester technology
  - Emits carbon dioxide, and generates energy

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Soil and Biomass Storage of CO_2

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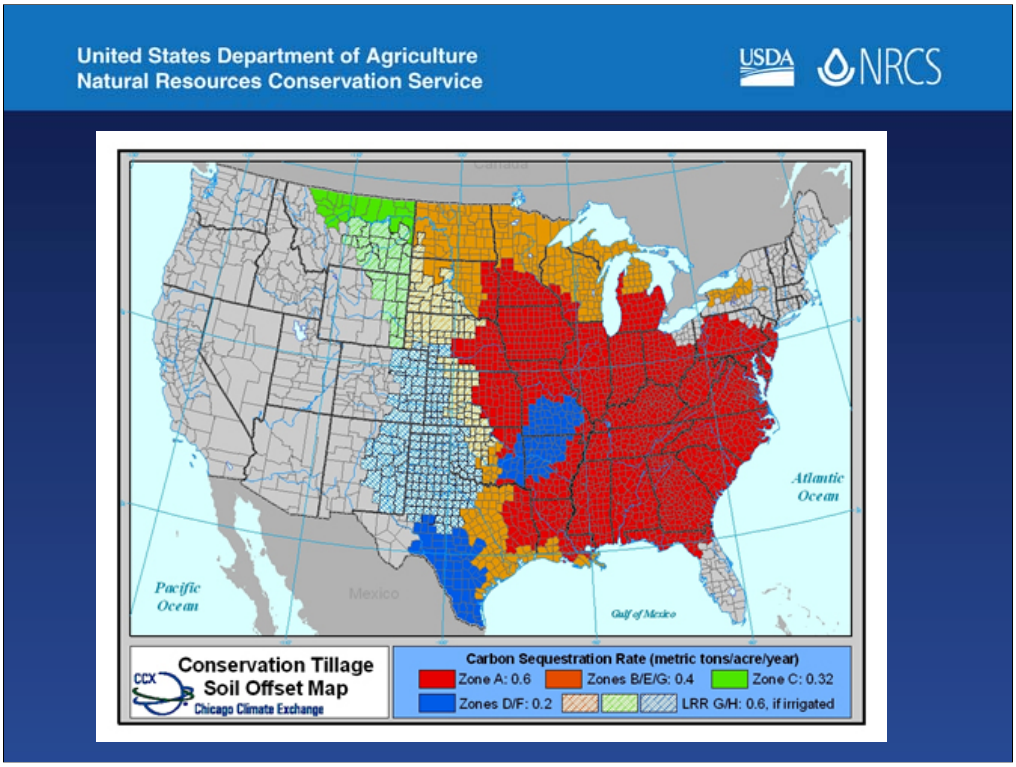
Predictive Tools

- CCX recommendations
- IPCC recommendations
- 1605(b) techniques
- Process models (Century, EPIC)
- Web-based (COMET-VR, COLE)



Map of zones for carbon sequestration rates from CCX.

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Cropland (not certified in OR)

Allowed (follow NRCS-329):

- no-till drill
- no-till and strip-till planters
- low disturbance liquid manure injectors, anhydrous ammonia applicator, manure knife applicator

Not Allowed:

- field cultivators, tandem disk, offset disk, chisel plow, moldboard plow
- Burning or residue removal

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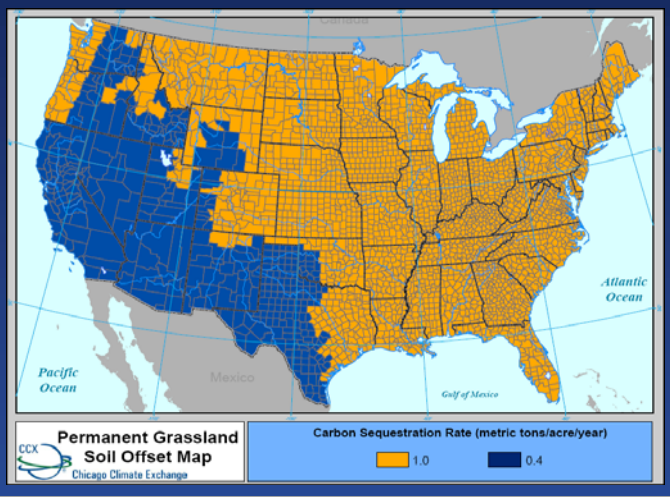
Grassland

- 0.4 to 1.0 tonnes/acre CO_2 equiv. in CCX eligible counties



For recently planted grasses (after 1999).

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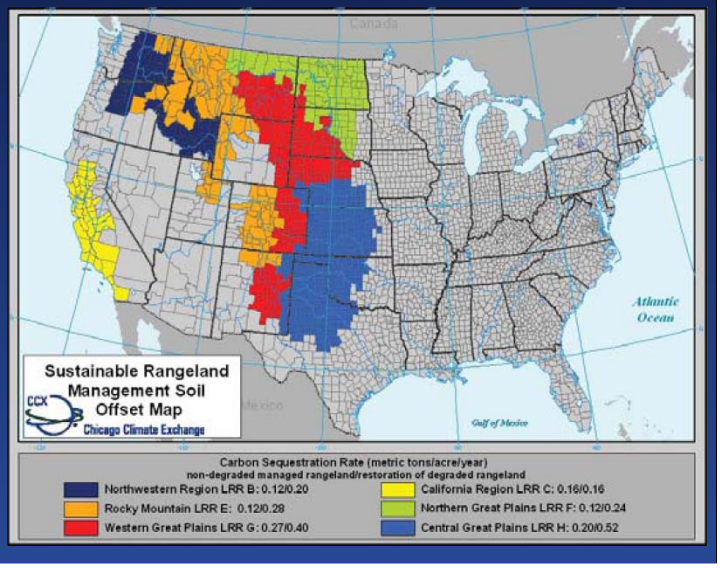
Rangeland

- .12 - .52 tons/acre/ yr



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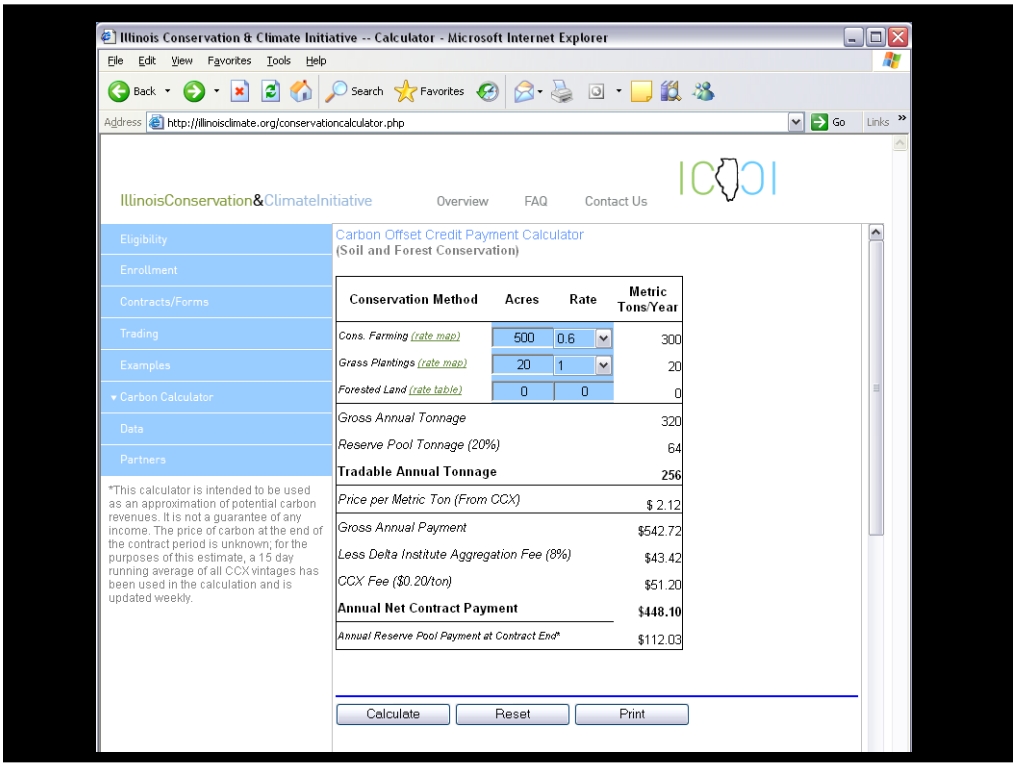
Forestry

- Based on stand type/age
- > stems per acre



http://illinoisclimate.org/calculator.php

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Intergovernmental Panel on Climate Change (IPCC)

- CO_2 – emissions factors based on land use, tillage, and inputs
- N_2O = .016 * N applied
- Applicable for national accounting

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COMET-VR

- **V**oluntary **R**eporting of Greenhouse Gases-**C**arb**O**n **M**anagement **E**valuation **T**ool
- Web-based interface to Century model
- Decision support for agricultural producers, land managers, and other agricultural interests
- Official USDA tool for estimating carbon sequestration

http://www.cometvr.colostate.edu

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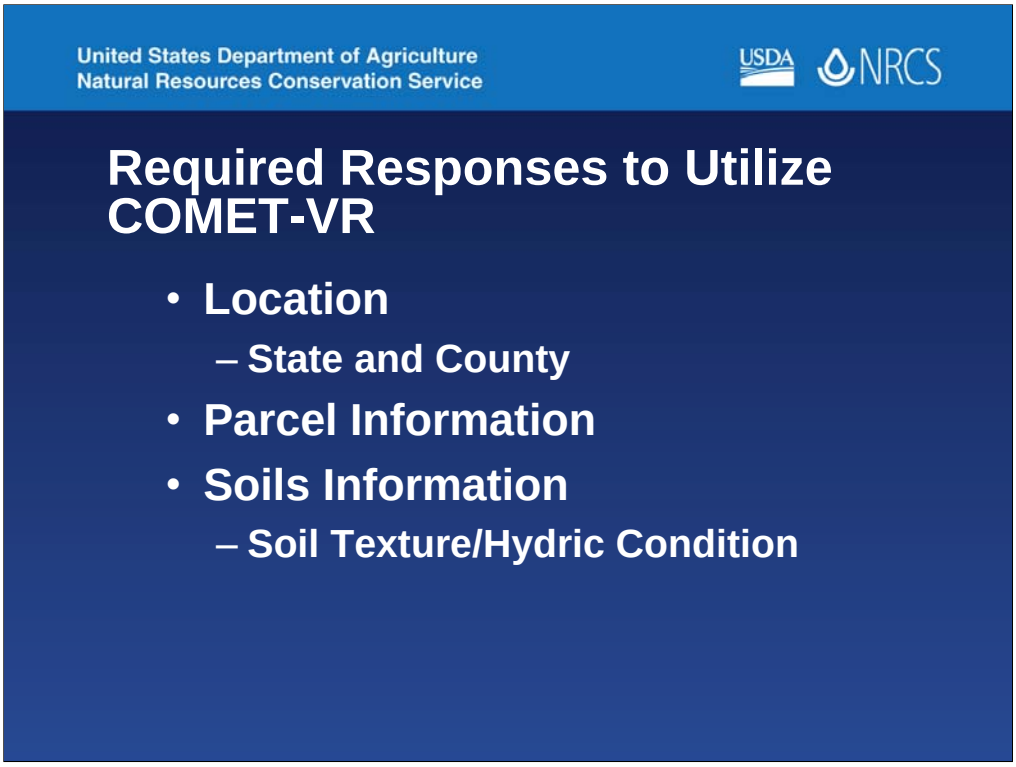
COMET-VR

- **Version 1.1**
- 226 MLRA's
- 20-40 rotation/cropping choices per MLRA
- 12 soil textures
- Century model w/
  improved uncertainty estimate



Required Responses to use COMET-VR: The tool requires 7 inputs by the user based on information that we feel land managers only know. The location is needed to determine climate data for the model run. Parcel information is for the user to identify which lands they are working on. Soils information is based on soil texture and hydric class which allows the model to capture artificially drained areas. We are only dealing with mineral soils in the version of COMET-VR. The management history is selected by the user and is limited at this time, but is currently being expanded to capture the systems as reported in the National Resources Inventory. Once all the data is entered, the user selects Get Carbon and the tool delivers a response in 5 seconds or less.

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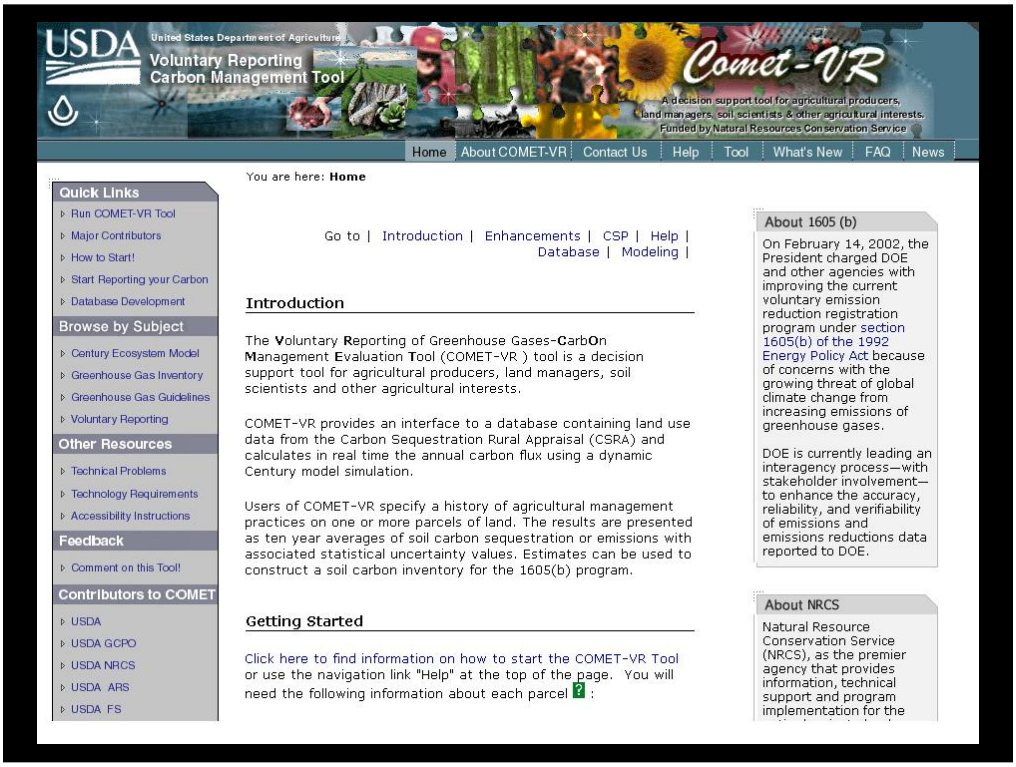
Required Responses to Utilize COMET-VR

- **Management History (crop rotations, tillage systems or grazing systems)**
  - **Pre 1970's**
  - **1970's-1990's**
  - **Base: 1990's-Current**
  - **Reporting Period: Current + 10 years**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Century Ecosystem Model
Greenhouse Gas Inventory
Greenhouse Gas Guidelines
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Technology Requirements
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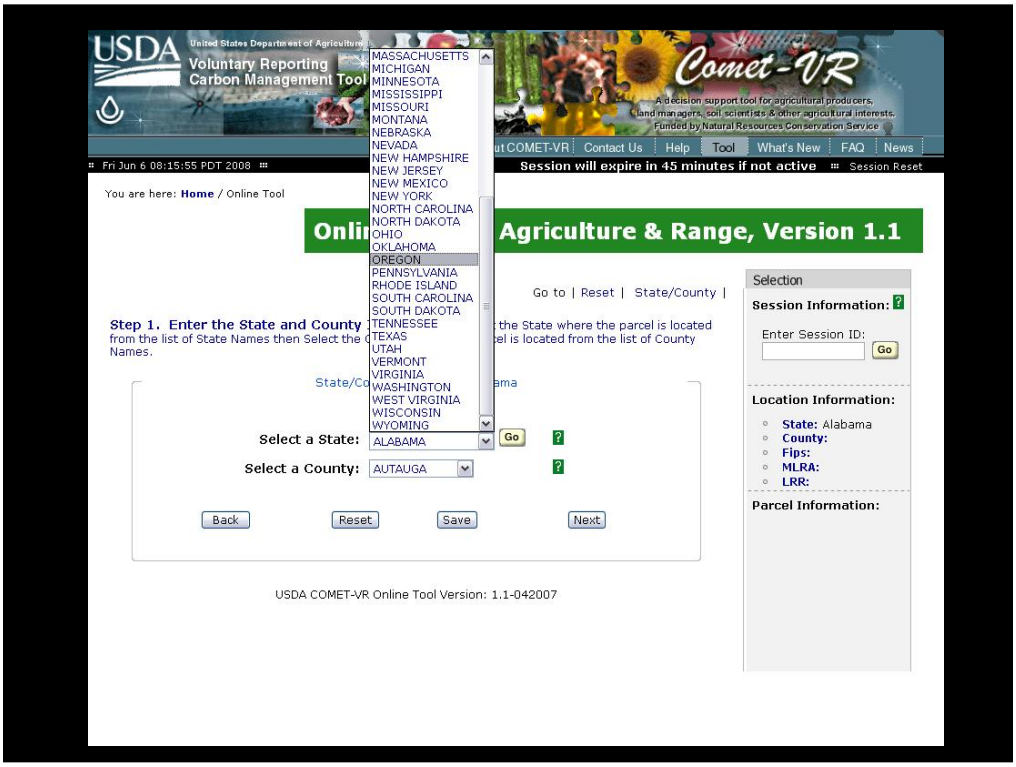
Go to | Introduction | Enhancements | CSP | Help | Database | Modeling |
Introduction
The Voluntary Reporting of Greenhouse Gases-CarbOn Management Evaluation Tool (COMET-VR) tool is a decision support tool for agricultural producers, land managers, soil scientists and other agricultural interests.
COMET-VR provides an interface to a database containing land use data from the Carbon Sequestration Rural Appraisal (CSRA) and calculates in real time the annual carbon flux using a dynamic Century model simulation.
Users of COMET-VR specify a history of agricultural management practices on one or more parcels of land. The results are presented as ten year averages of soil carbon sequestration or emissions with associated statistical uncertainty values. Estimates can be used to construct a soil carbon inventory for the 1605(b) program.
Getting Started
Click here to find information on how to start the COMET-VR Tool or use the navigation link "Help" at the top of the page. You will need the following information about each parcel :
About 1605 (b)
On February 14, 2002, the President charged DOE and other agencies with improving the current voluntary emission reduction registration program under section 1605(b) of the 1992 Energy Policy Act because of concerns with the growing threat of global climate change from increasing emissions of greenhouse gases.
DOE is currently leading an interagency process—with stakeholder involvement—to enhance the accuracy, reliability, and verifiability of emissions and emissions reductions data reported to DOE.
About NRCS
Natural Resource Conservation Service (NRCS), as the premier agency that provides information, technical support and program implementation for the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Fri Jun 6 08:15:55 PDT 2008
Session will expire in 45 minutes if not active
Session Reset
You are here: Home / Online Tool
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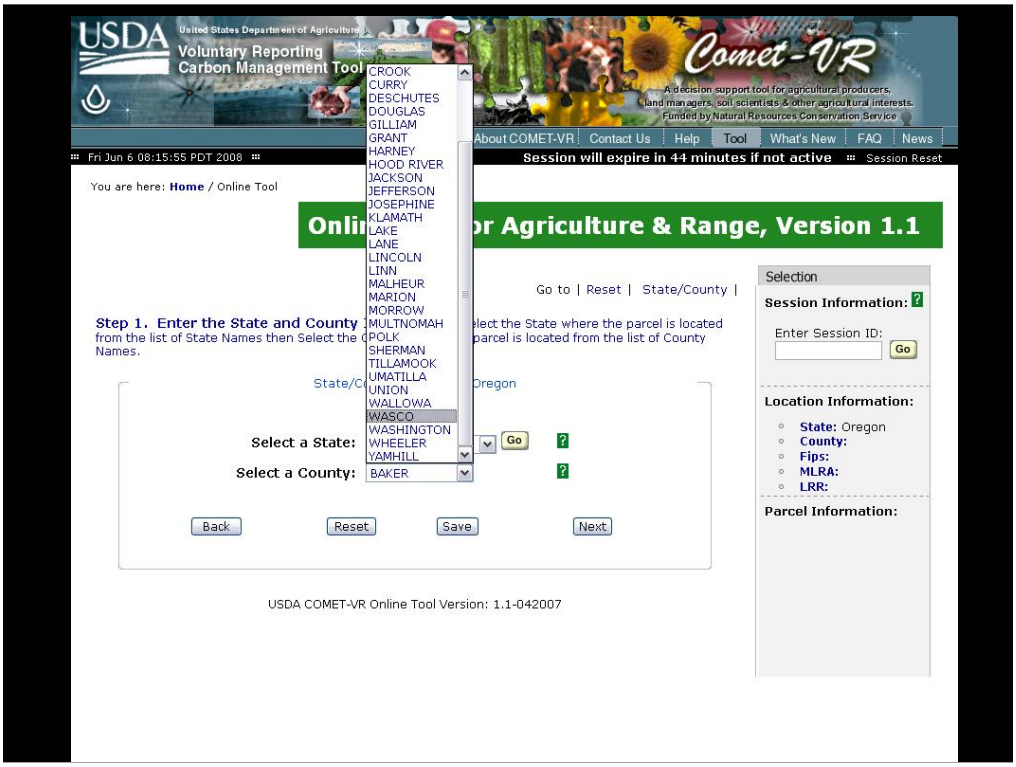
Go to | Reset | State/County |
Step 1. Enter the State and County
Select a State:
Select a County:
Go
Back
Reset
Save
Next
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Alabama
County:
Fips:
MLRA:
LRR:
Parcel Information:
USDA COMET-VR Online Tool Version: 1.1-042007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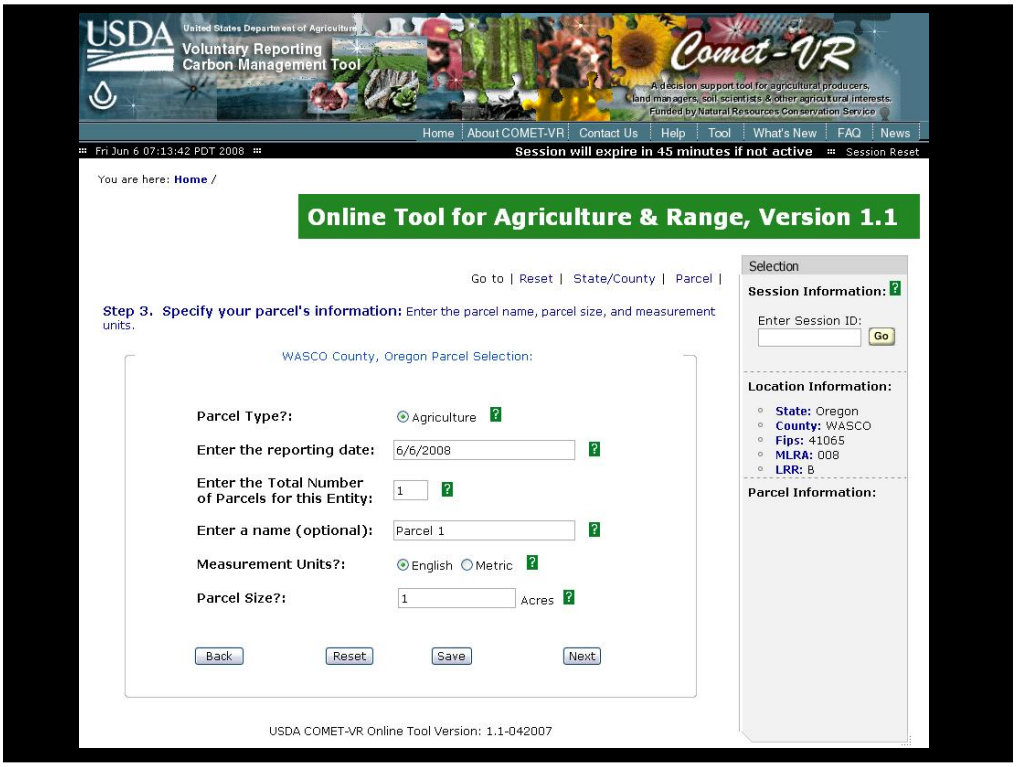
Session will expire in 44 minutes if not active
Session Reset
You are here: Home / Online Tool
Agriculture & Range, Version 1.1
Go to | Reset | State/County |
Step 1. Enter the State and County
Oregon
Select a State:
Go
Select a County:
BAKER
CROOK
CURRY
DESCHUTES
DOUGLAS
GILLIAM
GRANT
HARNEY
HOOD RIVER
JACKSON
JEFFERSON
JOSEPHINE
KLAMATH
LAKE
LANE
LINCOLN
LINN
MALHEUR
MARION
MORROW
MULTNOMAH
POLK
SHERMAN
TILLAMOOK
UMATILLA
UNION
WALLOWA
WASCO
WASHINGTON
WHEELER
YAMHILL
Back
Reset
Save
Next
USDA COMET-VR Online Tool Version: 1.1-042007
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County:
Fips:
MLRA:
LRR:
Parcel Information: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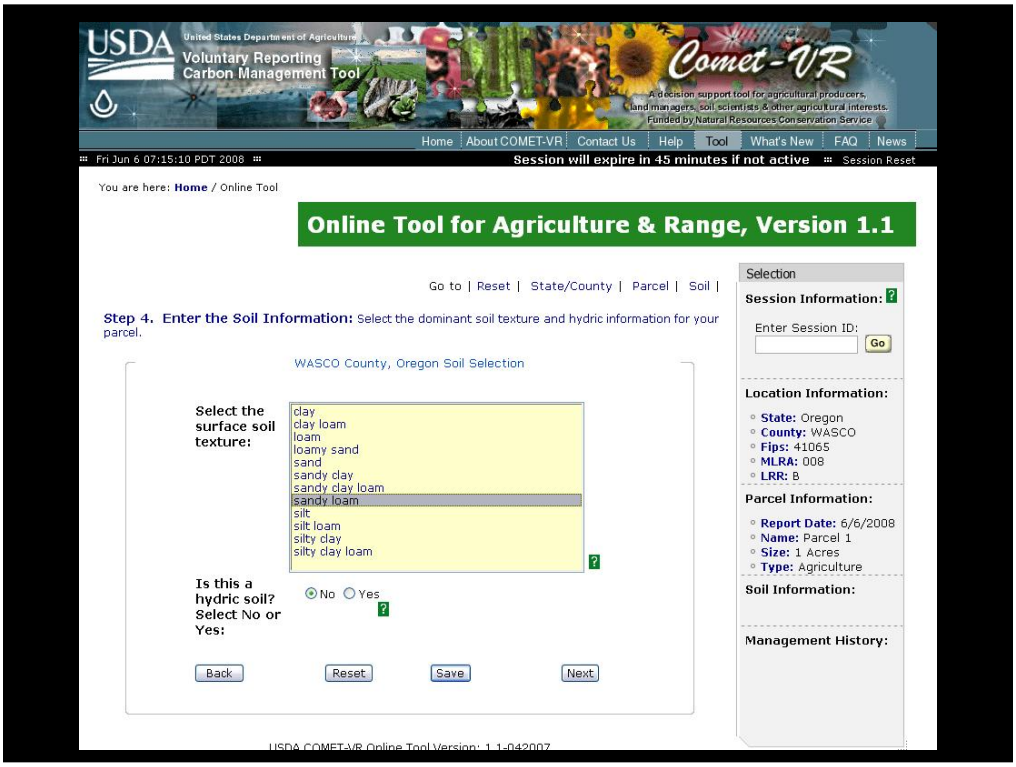
Online Tool for Agriculture & Range, Version 1.1
Go to | Reset | State/County | Parcel |
Step 3. Specify your parcel's information: Enter the parcel name, parcel size, and measurement units.
WASCO County, Oregon Parcel Selection:
Parcel Type?: Agriculture
Enter the reporting date: 6/6/2008
Enter the Total Number of Parcels for this Entity: 1
Enter a name (optional): Parcel 1
Measurement Units?: English Metric
Parcel Size?: 1 Acres
Back
Reset
Save
Next
USDA COMET-VR Online Tool Version: 1.1-042007
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County: WASCO
Fips: 41065
MLRA: 008
LRR: B
Parcel Information: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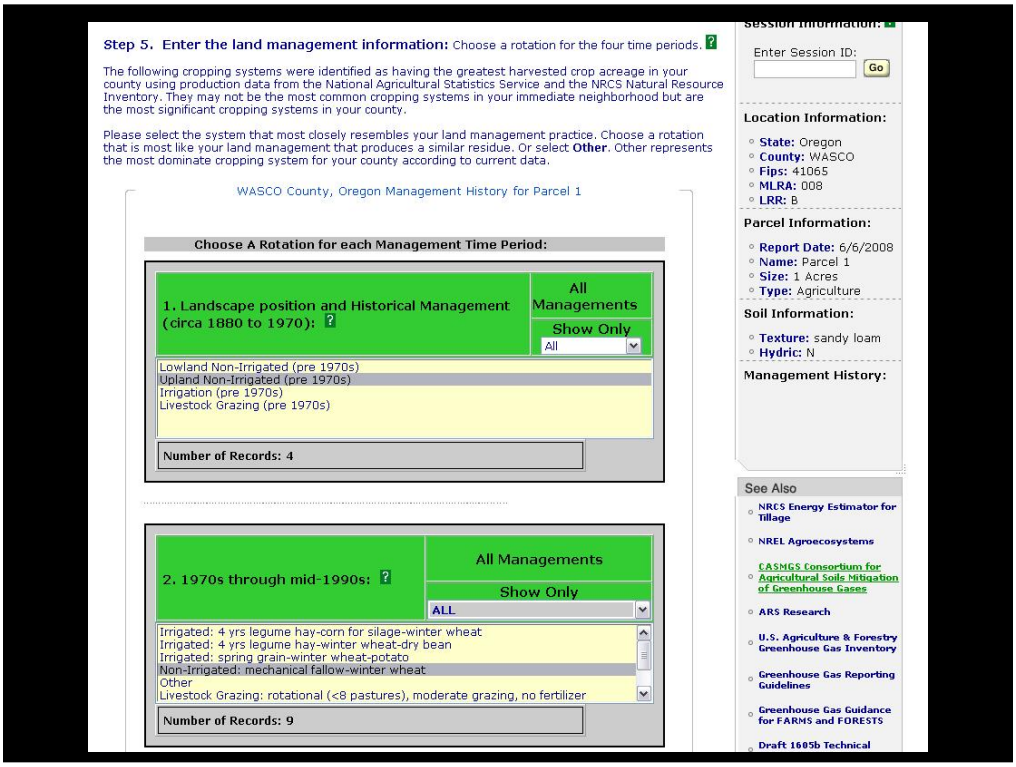
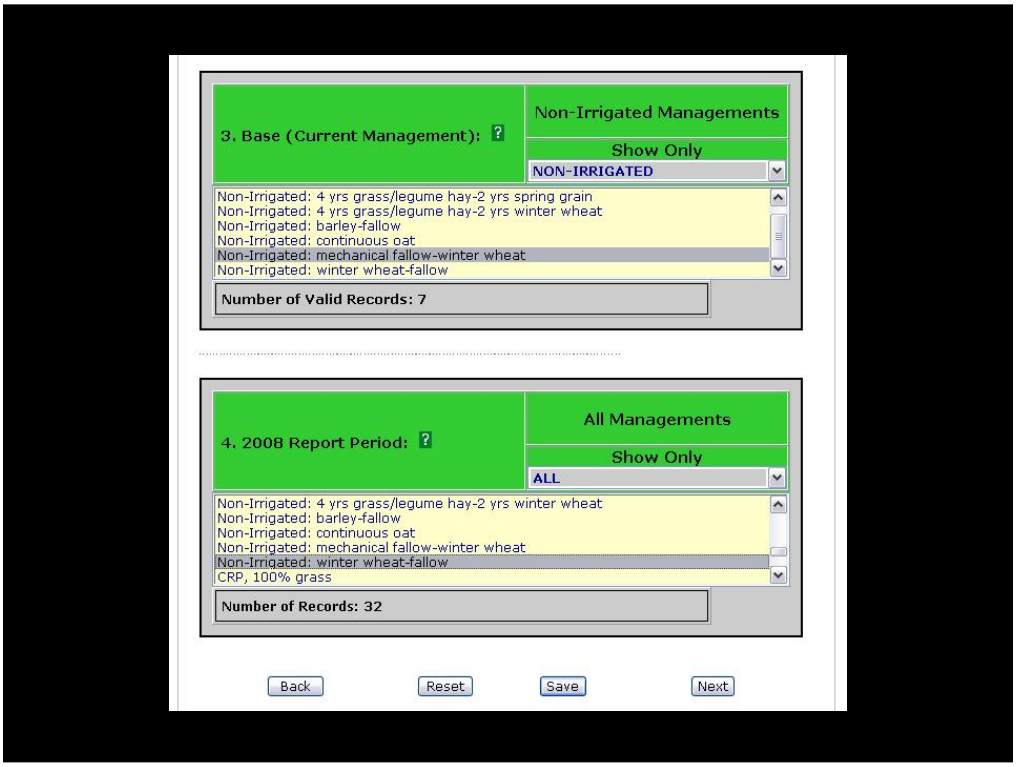
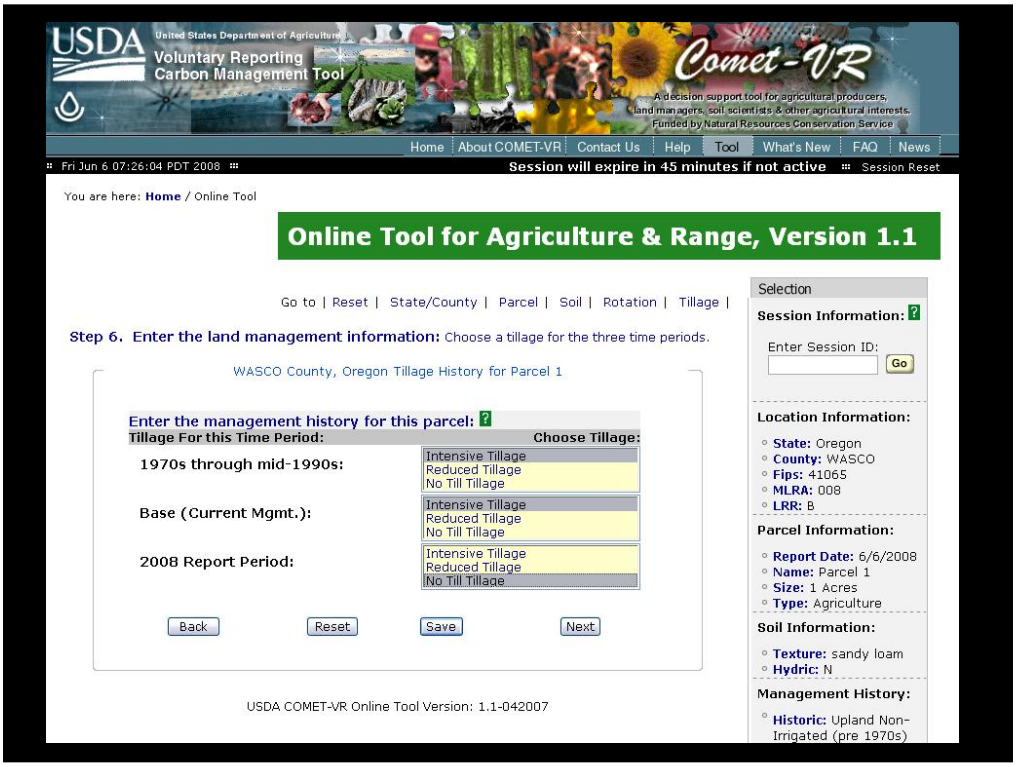
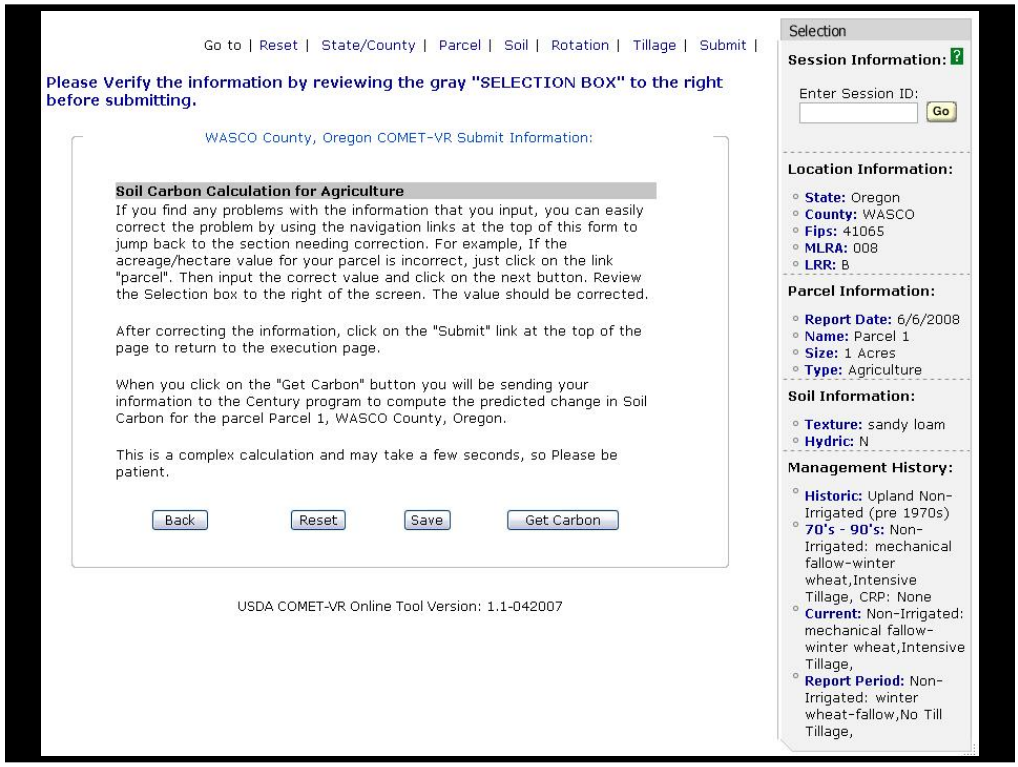
Session will expire in 45 minutes if not active
Session Reset
You are here: Home / Online Tool
Online Tool for Agriculture & Range, Version 1.1
Go to | Reset | State/County | Parcel | Soil |
Step 4. Enter the Soil Information: Select the dominant soil texture and hydric information for your parcel.
WASCO County, Oregon Soil Selection
Select the surface soil texture:
clay
clay loam
loam
loamy sand
sand
sandy clay
sandy clay loam
sandy loam
silt
silt loam
silty clay
silty clay loam
Is this a hydric soil? Select No or Yes:
No
Yes
Back
Reset
Save
Next
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County: WASCO
Fips: 41065
MLRA: 008
LRR: B
Parcel Information:
Report Date: 6/6/2008
Name: Parcel 1
Size: 1 Acres
Type: Agriculture
Soil Information:
Management History:
USDA COMET-VR Online Tool Version: 1.1-042007


Step 5. Enter the land management information: Choose a rotation for the four time periods.
The following cropping systems were identified as having the greatest harvested crop acreage in your county using production data from the National Agricultural Statistics Service and the NRCS Natural Resource Inventory. They may not be the most common cropping systems in your immediate neighborhood but are the most significant cropping systems in your county.
Please select the system that most closely resembles your land management practice. Choose a rotation that is most like your land management that produces a similar residue. Or select Other. Other represents the most dominate cropping system for your county according to current data.
WASCO County, Oregon Management History for Parcel 1
Choose A Rotation for each Management Time Period:
1. Landscape position and Historical Management (circa 1880 to 1970):
All Managements
Show Only
All
Lowland Non-Irrigated (pre 1970s)
Upland Non-Irrigated (pre 1970s)
Irrigation (pre 1970s)
Livestock Grazing (pre 1970s)
Number of Records: 4
2. 1970s through mid-1990s:
All Managements
Show Only
ALL
Irrigated: 4 yrs legume hay-corn for silage-winter wheat
Irrigated: 4 yrs legume hay-winter wheat-dry bean
Irrigated: spring grain-winter wheat-potato
Non-Irrigated: mechanical fallow-winter wheat
Other
Livestock Grazing: rotational (<8 pastures), moderate grazing, no fertilizer
Number of Records: 9
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County: WASCO
Fips: 41065
MLRA: 008
LRR: B
Parcel Information:
Report Date: 6/6/2008
Name: Parcel 1
Size: 1 Acres
Type: Agriculture
Soil Information:
Texture: sandy loam
Hydric: N
Management History:
See Also
NRCS Energy Estimator for Tillage
NREL Agroecosystems
CASMGS Consortium for Agricultural Soils Mitigation of Greenhouse Gases
ARS Research
U.S. Agriculture & Forestry Greenhouse Gas Inventory
Greenhouse Gas Reporting Guidelines
Greenhouse Gas Guidance for FARMS and FORESTS
Draft 1605b Technical


3. Base (Current Management):
Non-Irrigated Managements
Show Only
NON-IRRIGATED
Non-Irrigated: 4 yrs grass/legume hay-2 yrs spring grain
Non-Irrigated: 4 yrs grass/legume hay-2 yrs winter wheat
Non-Irrigated: barley-fallow
Non-Irrigated: continuous oat
Non-Irrigated: mechanical fallow-winter wheat
Non-Irrigated: winter wheat-fallow
Number of Valid Records: 7
4. 2008 Report Period:
All Managements
Show Only
ALL
Non-Irrigated: 4 yrs grass/legume hay-2 yrs winter wheat
Non-Irrigated: barley-fallow
Non-Irrigated: continuous oat
Non-Irrigated: mechanical fallow-winter wheat
Non-Irrigated: winter wheat-fallow
CRP, 100% grass
Number of Records: 32
Back
Reset
Save
Next


United States Department of Agriculture
Voluntary Reporting Carbon Management Tool
Comet-VR
A decision support tool for agricultural producers, land managers, soil scientists & other agricultural interests. Funded by Natural Resources Conservation Service
Home | About COMET-VR | Contact Us | Help | Tool | What's New | FAQ | News
Fri Jun 6 07:26:04 PDT 2008
Session will expire in 45 minutes if not active
Session Reset
You are here: Home / Online Tool
Online Tool for Agriculture & Range, Version 1.1
Go to | Reset | State/County | Parcel | Soil | Rotation | Tillage |
Step 6. Enter the land management information: Choose a tillage for the three time periods.
WASCO County, Oregon Tillage History for Parcel 1
Enter the management history for this parcel:
Tillage For this Time Period:
Choose Tillage:
1970s through mid-1990s:
Intensive Tillage
Reduced Tillage
No Till Tillage
Base (Current Mgmt.):
Intensive Tillage
Reduced Tillage
No Till Tillage
2008 Report Period:
Intensive Tillage
Reduced Tillage
No Till Tillage
Back
Reset
Save
Next
USDA COMET-VR Online Tool Version: 1.1-042007
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County: WASCO
Fips: 41065
MLRA: 008
LRR: B
Parcel Information:
Report Date: 6/6/2008
Name: Parcel 1
Size: 1 Acres
Type: Agriculture
Soil Information:
Texture: sandy loam
Hydric: N
Management History:
Historic: Upland Non-Irrigated (pre 1970s)


Go to | Reset | State/County | Parcel | Soil | Rotation | Tillage | Submit |
Please Verify the information by reviewing the gray "SELECTION BOX" to the right before submitting.
WASCO County, Oregon COMET-VR Submit Information:
Soil Carbon Calculation for Agriculture
If you find any problems with the information that you input, you can easily correct the problem by using the navigation links at the top of this form to jump back to the section needing correction. For example, If the acreage/hectare value for your parcel is incorrect, just click on the link "parcel". Then input the correct value and click on the next button. Review the Selection box to the right of the screen. The value should be corrected.
After correcting the information, click on the "Submit" link at the top of the page to return to the execution page.
When you click on the "Get Carbon" button you will be sending your information to the Century program to compute the predicted change in Soil Carbon for the parcel Parcel 1, WASCO County, Oregon.
This is a complex calculation and may take a few seconds, so Please be patient.
Back
Reset
Save
Get Carbon
USDA COMET-VR Online Tool Version: 1.1-042007
Selection
Session Information:
Enter Session ID:
Go
Location Information:
State: Oregon
County: WASCO
Fips: 41065
MLRA: 008
LRR: B
Parcel Information:
Report Date: 6/6/2008
Name: Parcel 1
Size: 1 Acres
Type: Agriculture
Soil Information:
Texture: sandy loam
Hydric: N
Management History:
Historic: Upland Non-Irrigated (pre 1970s)
70's - 90's: Non-Irrigated: mechanical fallow-winter wheat,Intensive Tillage, CRP: None
Current: Non-Irrigated: mechanical fallow-winter wheat,Intensive Tillage,
Report Period: Non-Irrigated: winter wheat-fallow,No Till Tillage,

Voluntary Reporting

Carbon Management Tool COMET-VR

Carbon Storage Report

Report Year: 2008

Session ID: 133560355

Parcel Description	
Parcel Type:	Agriculture
Total Parcels for this Entity:	1
Parcel Name:	Parcel 1
Parcel Size:	1 Acres
Location:	WASCO, Oregon
Soil:	Non-hydric sandy loam

Parcel Management History	
Historic:	Upland Non-Irrigated (pre 1970s)
70s to 90s:	Non-Irrigated: mechanical fallow-winter wheat; Intensive Tillage
Current:	Non-Irrigated: mechanical fallow-winter wheat; Intensive Tillage
Report Period:	Non-Irrigated: winter wheat-fallow; No Till Tillage

Predicted Change in Soil Carbon for the Parcel

Annual Change for 2008

	Carbon Change	Uncertainty		
		Avg Percent	Lower Bounds CI*	Upper Bounds CI*
Total Tons Carbon per year:	0.14	31.30 %	0.10	0.18
Total Tons CO2 Equivalent per year:	0.51	31.30 %	0.36	0.68

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Carbon Credit Trading

United States Department of Agriculture
Natural Resources Conservation Service

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Carbon Credit Trading

- Certified emissions reductions/sequestration
  - measured/modeled
- Aggregator Entity
- Trading Mechanism

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Aggregators

- Iowa Farm Bureau
- Farmers Union (North Dakota)
- Illinois Conservation and Climate Init.
- Beartooth Capital Partners (Montana)
- The Carbon Fund
- Environmental Credit Corporation
- Other new ones every day

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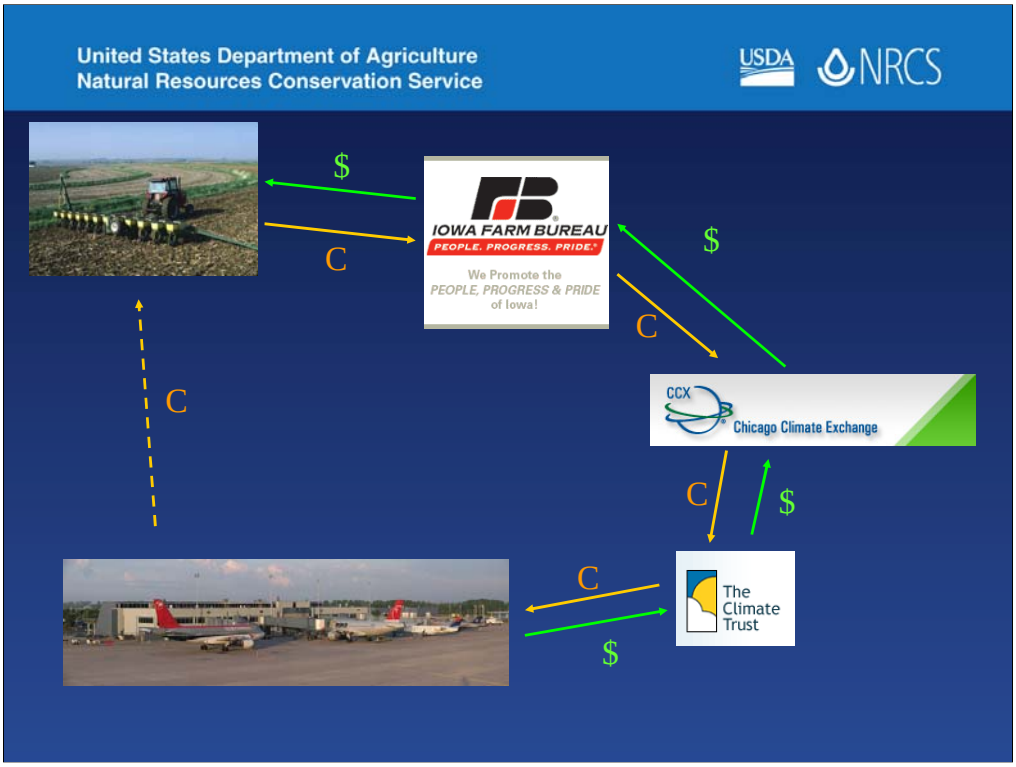
Trading – Chicago Climate Exch.

- "Chicago Climate Exchange (CCX) is North America's only and the world's first global marketplace for integrating voluntary legally binding emissions reductions with emissions trading and offsets for all six greenhouse gases."



Example of a carbon trade. Farmer no-tills, gains carbon credits. Sells them to an aggregator. The aggregator markets the credits on the Chicago Climate Exchange. Offsetters can purchase credits on CCX to market as greenhouse gas offsets. Private travelers can purchase credits to offset the "carbon footprint" of their travel.

United States Department of Agriculture
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Review:

- Sunlight and Thermal Radiation
- Greenhouse Effect and Global Temperature
- GHG's and Agriculture
- Methods of Estimating GHG Emission Reductions and Sequestration
- Carbon Credit Trading

United States Department of Agriculture
Natural Resources Conservation Service

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